THE general view held by philosophers seems to be that when temperature rises the gravitative attraction changes (if at all) by a function of temperature only. This leads to the results stated in the beginning of their letter by Dr. Lindemann and Mr. Burton. But it is commonly conceded that at present there is no trustworthy theory of gravitation, so that one seems entitled to suggest that any increment in the force may be a function of both mass and temperature. The simplest formula, that of the weighted mean temperature, brings the facts as at present known into line. It seems that we must await further data; for, of course, a fact, however slight, may shatter a theory lying in its course.

If M, m, μ are the masses of earth, kilogram, and milligram, we have the cases cited thus. When m alone rises in temperature the increment of its force on μ is $Gm\mu\alpha T/d^2$, and on M is $Gmm\alpha T/d^2$. The first is sensible, the second insensible, compared with the forces when cold. Again, when μ alone rises in temperature the increment of its force on m is $G\mu\mu\alpha T/d^2$, but the increment of the force of M (considered as an aggregate of μ particles) on m is $G\mu\mu\alpha T/d^2$, multiplied by

$$\frac{M}{\mu}\cdot\frac{M}{M+m}\cdot\frac{\mu+m}{\mu}=GMm\alpha T/d^2.$$

This is identical with the increment of force on m due to M (considered as a whole), and is sensible compared with the force when cold. The series forms a consistent whole.

If the increments are due to radiation and resonance (see NATURE for July 13 last), there is an acoustical parallel. A medium fork will set up resonance to a slight degree in a large fork, to a greater degree in a small fork, all the forks having one frequency.

I cannot understand how the idea arises that action and reaction would ever, on this theory, be unequal. Let the force of m on M, both cold, be F. When m only rises in temperature the force is $(F+f_1)$, and when M only rises it is $(F+f_2)$, f_2 being of a higher order than f_1. But in each of the three cases the attraction is mutual and equal between M and m.

As regards Cornu's results, I stated that we could "deduce nothing" from them, so there is a misapprehension. I made no attempt to reconcile his results with mine.

I do not consider that the indirect results obtained from Prof. Boys's research can be laid by the side of mine for comparison. In his experiment any rise of temperature would involve *both* masses. Supposing the increment is due to molecular or other agitation of m due to radiation in my case, in his case there would be an enormously greater agitation in m due to direct rise in temperature. I see no reason why this should not be one hundred times as great as the effect due to radiation. The weighted mean formula was used to account for the effects observed when *either* mass is heated. The case when *both* masses are heated is different, and has not been at present considered, the data at hand being indirect and inconclusive.

The probable result from my experiments is $\alpha=+(1{\cdot}2\pm0{\cdot}05)\times10^{-5}$, or, as amended recently at Newcastle, $\alpha=+(1{\cdot}3\pm0{\cdot}05)\times10^{-5}$. Thus, while individual results differ among themselves, in some cases, by as much as the whole effect, yet the collective result is not weak.

I wish to express my appreciation of the generous terms used regarding my experiments by the authors.

P. E. SHAW.

University College, Nottingham, December 13.

THE USE OF METEORITIC IRON BY PRIMITIVE MAN.

METEORITES, as they reach our planet, are of three different kinds, namely, *siderites*, composed chiefly of nickel-iron; *aerolites*, composed chiefly of stony matter; and *siderolites*, composed of a mixture of iron and stone. The first and third only are of interest to us in this inquiry.

Great diversity of opinion has always prevailed among archæologists concerning the source of iron used in antiquity before it was intelligently produced from the ore. On the whole these opinions are about equally divided, though perhaps the majority are inclined to the verdict that meteoritic iron was *not* used by primitive man, for the following reasons:—First, because nearly all iron implements of antiquity extant, at least from the Old World (including the piece found in the Great Pyramid of Cheops), are of terrestrial origin; secondly, because it was believed to be non-malleable; thirdly, because it was said to be too scarce; and fourthly, because it was argued that small fragments could not have been detached from meteoritic masses by the means available to primitive man.

There is, to the casual observer, a great deal of truth in these four arguments, and they prove that there were several sporadic sources from which the early iron was drawn; perhaps in one locality they were chiefly terrestrial, while the use of extra-terrestrial or meteoritic iron predominated in other localities.

The fact that iron, in the earliest ages and from whatever source, was extremely rare is beyond all doubt. One might say that it was at least as rare as, and perhaps more valuable than, gold. It might therefore be asked: If meteoric iron was so rare and valuable, why was it not more carefully preserved by the people of antiquity? For, whereas we have plenty of gold objects of ancient workmanship in our museums, those of meteoritic iron are conspicuous by their absence. To this we may safely reply that the value of the meteoritic iron lay in its actual employment in the form of tools, implements, and weapons, and to have hidden such objects in treasure stores would have nullified their value, and that is one reason at least why so few were preserved. This disposes of argument number one.

We must bear in mind also that in the New World this argument does not apply with the same force, as we shall see that objects of meteoritic iron are not so rare there as in the Old World. The reason for this is that, whereas iron was produced in the Old World from the ore more than three thousand years ago, it was not introduced into the New World until the discovery of that continent about four hundred years ago, and it is obvious that objects more than three thousand years old have become rarer in our day than those comparatively new ones of only four hundred years ago.

A paper on this subject was contributed by the present writer at the autumn meeting of the Iron and Steel Institute. One of the principal features of this paper is a table including practically all known falls of meteoritic iron, their original weight, whether malleable (that is, suitable for being wrought into objects of utility) or non-malleable (not suitable for such purposes). This table was compiled with the object of removing all doubt concerning argument number two. The *résumé* of this table gives us the amount of meteoritic iron known at the present day—about 250 tons. Of this total the very considerable amount of more than 99 per cent. is malleable. Since this considerable mass of approximately 250 tons has been accumulated practically within the last century, we might dispose of argument number three, concerning the scarcity of meteoritic iron.

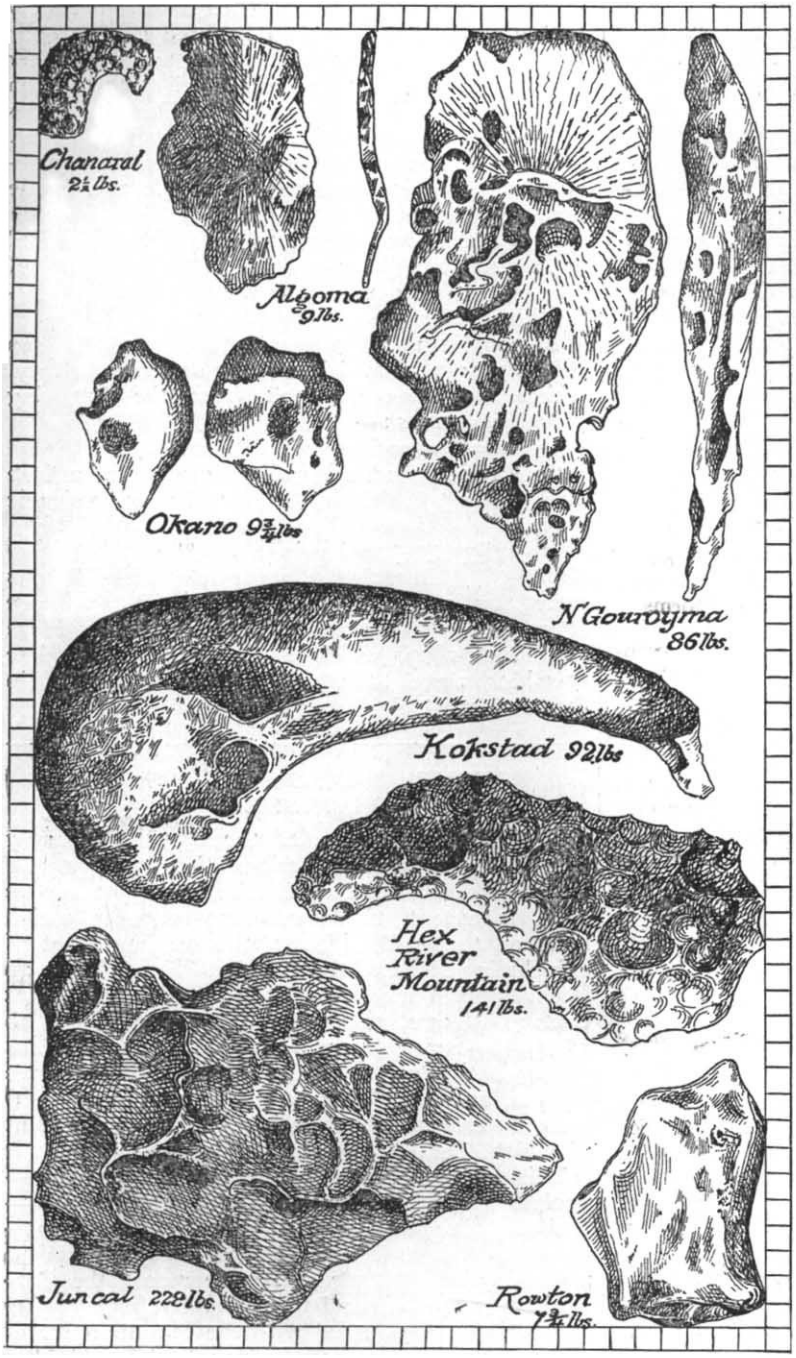

Chanaral 2½ lbs.
Algoma 9 lbs.
Okano 9¾ lbs
N'Gouroyma 86 lbs.
Kokstad 92 lbs
Hex River Mountain 141 lbs.
Juncal 228 lbs.
Rowton 7¾ lbs.

Fig. 1.—A number of iron meteorites showing their fragmentary form, from which it will be seen that some might be used entirely to form weapons and implements, whilst the protuberances of others might be cut off by primitive implements in order to form other weapons. Algoma, N'Gouroyma, and Okano are shown in two views each. Rowton is the only British specimen known; it fell near Wellington, Shropshire, on April 20, 1876. These meteorites are all drawn to the same scale, each square surrounding the illustration representing 1 in.

This *résume* cannot be surprising, as meteoritic iron is, generally speaking, pure iron-nickel alloy, such as we are now producing artificially; and the latter is certainly ductile and malleable.

The general appearance of the majority of meteorites gives one the impression that they were fragmentary, and suggests that they formed portions of larger masses. A single fall might spread over a considerable area, and it is obvious that many masses of known falls must thus be difficult to find, or be lost, particularly such smaller pieces as might be wrought into useful objects.

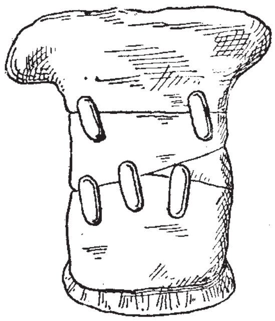
The accompanying illustration (Fig. 1) shows the fragmentary form of a few masses of meteoritic iron, from which we see that it is not like a cannon-ball, as is frequently supposed, and that it should not be so very difficult to sever such fragments. This disposes of argument number four.

Meteoritic iron was cut by the ancients in the same way as they cut pieces off the large masses of native copper found on the banks of Lake Superior, though it is not of course suggested that iron can be cut as readily as copper. When Cortez completed the conquest of Mexico the Spaniards noticed that the Aztecs possessed knives, daggers, etc., made of iron, and the question as to whence they had procured this iron became a perplexing problem to the Spaniards, which they were never able to solve. When asked, the natives mysteriously pointed to the sky, and indicated that they obtained their iron from the regions above. It was left to science to unravel the mystery. The

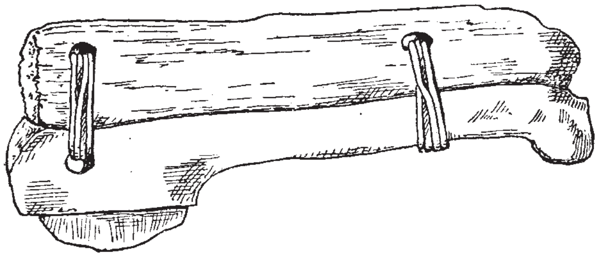
Aztecs were quite correct; the iron of which they had made their implements had come to them from the unknown regions of space, and was, in fact, of meteoritic origin.

Others, including Eskimos, certain Indian tribes, and the inhabitants of Yakutsk, in Eastern Siberia, used weapons and implements of meteoritic iron.

It would be impossible to mention here, even briefly, all the numerous meteorites of note which have fallen from time to time since the very earliest days. We may mention, however, in passing, the large meteorite which fell in the time of Pindar, 403 B.C., at Ægos Potamos, which is recorded in the Parian Chronicle, engraved in marble; and the stone at Orchomenos, of which Pausanias says that it fell from heaven before the siege of Troy, and during the reign of King Eteocles. Many falls are also mentioned by Pliny. Livy alone mentions twenty-one falls in fifty-one years which fell during his lifetime. Another meteorite of note is the stone in the Kaaba, the most sacred jewel of Islam, called "The right hand of God on earth," which was probably worshipped formerly at the temple sacred to the Moon that used to stand in Mecca. These few examples will show how well it was understood in antiquity that meteorites came from an extra-terrestrial source; this is also the reason why, in practically all the languages of antiquity, iron is called "metal of heaven." The author believes that the very word *metal*, from the Greek verb *metallao*—"to search diligently for other things"—has reference to the diligent search which had to be made by the people of antiquity for meteoritic iron, being the "other things" more coveted by them than their usual raw material, namely, stones.



"Oodoo" or woman's knife; the handle is of ivory.



"Savik" or man's knife (actual length, 4 in.); the handle is of wood and bone.

FIG. 2.—Ancient Eskimo knives made from the Melville Bay meteorite found by Rear-Admiral R. E. Peary.

If we compare the mention of meteorites in ancient and modern literature, it would almost seem that meteorites were more plentiful in olden times; for we must bear in mind that when primitive man used iron first, he used it most probably in the same way in which he used copper 8000 B.C.—that is, for pins and needles, and such other objects in which, for instance, small flakes of iron could be inserted in bone handles, like the knives and other implements of the Eskimos (Fig. 2). Where larger masses were used they were probably employed in the same way and form as stone axes and adzes with the haft tied on. Better chisels and knives were probably not made until experience had been gained in the making of needles and pins, and after the use of the smith's fire was understood.

In conclusion we may say that primitive man before 1200 B.C. used iron more or less sparingly, which iron was obtained from the following sporadic sources:—

(*a*) Iron meteorites.

(*b*) Chance productions by a camp fire, a flash of lightning, a forest fire, or through volcanic agency.

(*c*) Telluric or native iron.

We thus see that in using the nickelliferous meteoritic iron primitive man had the advantage of a metal that was not available to modern man until 1809, which is the approximate date at which nickel steel was first manufactured in the modern steel industry.

G. F. ZIMMER.

SURVEY WORK IN THE SINAI PENINSULA.[1]

IN the latest volume of the Egyptian Survey Dr. John Ball describes the geology and geography of an oblong district about 380 square miles in extent, the south-west angle of which rests on the Gulf of Suez, the northern part of it including some of the Gebel el Tih. This is an intensely dissected limestone plateau of about Cretaceous age, rising to nearly 4000 ft., with northward-facing scarps. South of this comes an undulating sandy upland, about 1600 ft. above the sea, and then (forming about half the district) a highly eroded mountain tract, the highest point of which, Serabit el Khâdim, reaches 3596 ft.

This tract consists mainly of crystalline rocks—gneisses, granites, diorites, and porphyries—probably Archæan, capped in places with sedimentaries. Of these the oldest are two sandstones, parted by a limestone, which represent the Carboniferous system, and the latter is shown by its fossils to be homotaxial with the Mountain Limestone in the North of England. The Nubian Sandstone, some 2000 ft. in thickness, which is, roughly speaking, Cenomanian in age, succeeds the upper of these sandstones without any marked break, and its lower part, as it is almost unfossiliferous, may represent something older. In one district, however, it includes carbonaceous

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[1] "Survey Department, Egypt. The Geography and Geology of West-Central Sinai." By John Ball, Ph.D., D.Sc., etc. Pp. xi+219+xxiv plates and 54 illustrations in the text. (Cairo: Government Press.) Price P.T. 30.